Flowers and insects. XIV.

CHARLES ROBERTSON.

GENTIANA PUBERULA Michx.—From the abundant observations on European species of *Gentiana* it appears that most of the species which have been investigated are proterandrous, though several are homogamous and a few proterogynous. Most of them are adapted to bumblebees, many to Lepidoptera, while quite a number are intermediate, being visited by both kinds of insects. One species, *G. lutea*, has exposed nectar, and is visited by a miscellaneous list. Nothing has been done with our species, except *G. crinita* and *Andrewsii*.

In the case of *G. Andrewsii*, Beal (6) observed that it was visited by bumblebees, but overlooked the proterandry, supposing that cross-pollination was favored by the stigma standing far above the anthers. A statement of Meehan, that the flower never opens, evidently taking it for granted that it is never visited by insects, is quoted by Henslow (12) in spite of Beal's observations. Vausenburg (10) objects to Beal's conclusions, and supposes that the stigma is pollinated as it passes the anthers. Kunze (18) regards the flower as cleistogamous, the nectar being of no significance. Bailey (17) records that nectar is secreted by the walls of the corolla. Gray (19, 21, 25) states that the flower opens a short time in sunshine, which I have never observed; notes the proterandry and that spontaneous self-pollination may finally occur by the lobes of the stigma curling back until they touch the anthers. Finally I have shown the adaptation to bumblebees and have recorded the abundant visits of *Bombus americanorum* F. ♂♀☿ (41). According to Beal (6) *G. crinita* is visited by bumblebees and resembles *G. Andrewsii*, of which, however, as we have noted, he had failed to recognize the proterandry.

G. Andrewsii and *puberula*, the only species I have found in my neighborhood, are the very latest of the bumblebee flowers, the former beginning to bloom by September 14th, and the latter on the 27th, both running nearly through October.

Gentiana puberula has the stem terminated by a cluster of

handsome bright blue flowers. The corolla measures about 5^{cm}, and the lobes expand horizontally about 3.5^{cm}. The tube is narrowed for about 17^{mm}, the bases of the filaments being attached to the tube for that distance. The free ends of the filaments bend inwards, holding the anthers in a cluster around the style. Bees insert their proboscides between the filaments, and these organs must be 17^{mm} long to exhaust the nectar. The flowers are strongly proterandrous and are adapted to bumblebees. I have seen them visited by *Bombus americanorum* F. ♂♀.

While the flowers of this plant are more conspicuous than those of *G. Andrewsii*, their pollen is not so well protected. Small bees and flies may enter the corollas and remove the pollen without being of any service, but this is prevented in *G. Andrewsii* by the lobes remaining closed.

On the literature of Gentiana see:

(1) Sprengel, Das entdeckte Geheimniss, 150–2. 1793. *G. Pneumonanthe*, proterandry, etc.—(2) Axell, Om anordningarna för de fanerogama växternas befruktning. 1869. *G. Pneumonanthe*, 27, ref. (1). *G. nivalis, lingulata*, homogamous, etc., 101.—(3) Ricca, Osservazioni sulla fecondazione incrociata dei vegetali alpini e subalpini. Atta della Soc. Ital. di Scienze naturale **13**: 254–63. 1870. **14**: 245–64. 1871. *G. acaulis, germanica, verna.*—(4) Kerner, Schutzmittel des Pollens 26, 44. 1873.—(5) Müller, Befruchtung der Blumen 332–3. 1873. *G. Pneumonanthe, Amarella*, pollination.—(6) Beal, The fertilization of gentians by humblebees. Am. Nat. **8**: 180, 226. 1874.—(7) Meehan, Fertilization of Gentiana. Proc. Acad. Nat. Sci. Philad. **1874**: 160. Proterandry, closed fl. seems to make insect pollination difficult.—(8) Delpino, Ulteriori osservazioni, Pt. II. 2: 162, 173, 180. 1875. *G. acaulis, asclepiadea, ciliata, pannonica*, nectar receptacle and guides, proterandry, etc.—(9) Lubbock, British wild flowers in relation to insects, 29, 127. 1875. *G. Pneumonanthe, Amarella.*—(10) Vausenburg, Gentiana Andrewsii. Am. Nat. **9**: 310. 1875.—(11) Kerner, Die Schutzmittel der Blüthen gegen unberufene Gäste. Festschrift Zool.-Bot. Gesellsch. Wien. 1876. Several spp.—(12) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. **1**: 326. 1877. Self-pollination by retention of corolla.—(13) Müller, Alpine species of Gentiana. Nature **15**: 317–19, 473–5. *f. 94–115*. 1877. Several spp.—(14) Müller, Geschichtliche Entwickelung der Gattung *Gentiana*. Kosmos **1**: 162–3. 1877. Abstract of (13)—(15) Müller, Fertilization of flowers by insects. Nature **16**: 265. 1877. *G. Bavarica, verna*, visits of Macroglossa.—(16) Burton, Gentiana asclepiadea and bees. Nature **17**: 201–2. 1877. Perforation.—(17) Bailey, Notes from Rhode Island. Bull. Torr. Bot. Club. **6**: 173. 1877.—(18) Kunze, Cleistogene flowers. ibid. 174. 1877.—(19) Gray, Gentiana Andrewsii. ibid. 179. 1877.—(20) Meehan, Gentiana Andrewsii. ibid. 189. 1877. Stigma receptive after becoming exposed above corolla, etc.—(21) Gray, Note to the review of Darwin's "Forms of Flowers." Am. Jour. Sci. and Arts. III. **15**: 221. Reply to (20).—

(22) Müller, Die Insekten als unbewusste Blumenzüchter. Kosmos **3**: 407, 425, 482. 1878. *G. Bavarica*, *excisa*, *lutea*, *verna*.—(23) Müller, Die Wechselbeziehungen zwischen den Blumen und den ihre Kreuzung vermittelden Insekten. Encycl. der Narturwiss. Breslau **5**: 62. 1879. *G.* subgen. *Cyclostigma*, change from bumblebee to butterfly fls. in Alps.—(24) Bonnier, Les Nectaires. 1879. *G.*, 116, *campestris*, 143.—(25) Gray, Structural Botany 240. 1880.—(26) Müller, Bombus mastrucatus, ein Dysteleolog unter den alpinen Blumensuchern. Kosmos **5**: 422–31. 1880. *G. acaulis*, *asclepiadea*, *campestris*, perforation.—(27) Müller, Die Falterblumen des Alpenfrühlings und ihre Liebesboten. Kosmos **6**: 446–56. 1880. *G. verna*.—(28) Thompson, Fertilization of New Zealand flowering plants. Trans. & Proc. New Zeal. Inst. **13**: 241–88. 1880. *G. montana*, proterandrous, etc.—(29) Müller, Die Alpenblumen, ihre Befruchtung durch Insekten, und ihre Anpassungen an dieselben 329–49. 1881. *G. acaulis*, *asclepiadea*, *Bavarica*, *campestris*, *ciliata*, *lutea*, *nana*, *nivalis*, *obtusifolia*, *punctata*, *tenella*, *verna*, with notes on others and review of genus.—(30) Müller, Die Entwickelung der Blumenthätigkeit der Insekten. Kosmos **9**: 258–72, 351–70. 1881. *G. acaulis*, *Bavarica*, *punctata*, *verna*.—(31) Müller, Fertilization of flowers, 402–6. 1883. *G. Pneumonanthe*, *Amarella*, notes on others and review of genus.—(32) Warming, Om Nogle Arktiske Vaexters Biologi. Bihang till K. Svenska Vet.-Acad. Handlingar **12**: 8–12. 1886. *G. nivalis*, *tenella*, *Pneumonanthe*, *involucrata*, *Amarella*, *campestris*.—(33) Loew, Weitere Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des botanischen Gartens zu Berlin. Jahrb. bot. Gartens Berlin **4**: 128–9. 1886. *G.*, Müller on development of.—(34) Huxley, The gentians. Notes and queries. Journ. Linn. Soc. **24**: 101–24. 1887. On the family.—(35) Lindman, Blühen und Bestäubungseinrichtungen im Skandinavischen Hochgebirge. Bot. Centralblatt **30**: 159. 1887. *G. campestris*, *nivalis*, self-pollination.—(36) Pammel, On the pollination of Phlomis tuberosa and the perforation of flowers. Trans. St. Louis Acad. Sci. **5**: 257–8, 474. 1888. Perforation.—(37) Schulz, Beiträge zur Kenntniss der Bestäubungeinrichtungen und Geschlechtsvertheilung bei den Pflanzen. I. 1888. II. 1890. Bibliotheca Botanica. I. *G. germanica*, *Amarella*, *ciliata*, II. *G. acaulis*, *excisa*, *verna*, *campestris*, *obtusifolia*, *ciliata*, also 14 spp. perforated by Bombus.—(38) Hansgirg, Ueber d. Verbreitung d. reizbaren Staubfäden u. Narben, sowie d. sich periodisch oder blos einmal öffenden u. schliessenden Blüten. Bot. Centralblatt **43**: 415. 1890. *G. acaulis*, *Saponaria*, opening and closing of fls.—(39) Kirchner, Beiträge zur Biologie der Blüthen. Progr. z. 72 Jahresfeier d. Kgl. Würtemb. landwirthschaftl. Akademie Hohenheim 47–49. 1890. *G. purpurea*, *tenella*.—(40) Kerner, Pflanzenleben **2**: 1891. Several spp.—(41) MacLeod, De Pyreneeënbloemen en hare bevruchting door insecten. 1891. *G. verna*, visitors, 343.—(41) Robertson, Flowers and insects. Asclepiadaceæ—Scrophulariaceæ. Trans. St. Louis Acad. Sci. **5**: 577. 1891.—(42) Hansgirg, Neue biologische Mittheilungen. Bot. Centralblatt **52**: 387. 1892. *G. phlogifolia*, *Fetisowii*, opening and closing of fls.—(43) Hansgirg, Biologische Fragmente. Bot. Centralblatt **56**: 258. 1893. *G. campestris*, opening and closing of fls.—(44) MacLeod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek **5**: 381. 1893. *G. Pneumonanthe*.—(45) Knuth, Blumen und In-

sekten auf den Nordfriesischen Inseln 105. 1894. *G. Pneumonanthe.*—(46) Loew, Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands. Systematische Zusammenstellung des in den letzten zehn Jahren veröffentlichten Beobachtungsmaterials. 1894. 25 species.

FRASERA CAROLINENSIS Walt.—American columbo.—In the GAZETTE **18:** 48–9, the view was expressed that the hairy crest about the nectaries serves as a foothold, besides concealing the nectar. Its importance as a foothold, however, is not great. It was also supposed that bumblebees might prove to be the principal guests, though they had not been observed about the flowers at that time. In 1894 the flowers were in bloom from May 24th to June 22nd. On May 30th and June 1st, 4th, 8th and 12th the following visitors were noted:

Apidæ: (1) Apis mellifica L. ☿, ab.; (2) Bombus separatus Cr. ☿☿, the most abundant visitor; (3) B. americanorum F. ☿, one; (4) Anthophora abrupta Say ♂♀, freq.

Rhopalocera: (5) Eudamus pylades Scud.—all sucking.

Several species of Andrenidæ, principally *Halictus* and *Augochlora*, visit the flowers for nectar and pollen, but are too small to effect pollination.

PHLOX GLABERRIMA L.—This plant is rather rare. It grows on prairies and was noted in bloom from May 28th to July 30th. The stems grow from 4 to 8^{dm} high, bear handsome corymbs of purple flowers and are often collected in large patches. The border expands about 20^{mm}, and the tube is from 16 to 18^{mm} long. There is a slight appearance of proterandry, but I think that, in case insect visits fail, spontaneous self-pollination may occur by the stigma receiving pollen from the nearest anthers. There is a chance that an insect's proboscis may carry pollen from the long stamens back to the stigma, though the anthers of the long stamens dehisce first. This species agrees with all of the species of *Phlox* which have been observed in being adapted to butterflies. The anthers of the long stamens are so exposed at the mouth of the tube that their pollen is sometimes stolen by syrphids, *Syrphus americanus* Wd., etc. On seven days, between May 28th and July 18th, the following visitors were observed, all sucking:

Lepidoptera—*Rhopalocera:* (1) Danais archippus F.; (2) Colias philodice Gdt.; (3) Papilio thoas L.; (4) P. asterias F.; (5) P. philenor L.; (6) Pamphila peckius Kby.; *Heterocera:* (7) Scepsis fulvicollis Hbn.

PHLOX PILOSA L.—This species is common on prairies, growing in large patches. The flowers are pinkish. The border is about 20^{mm} wide, the tubes 10 to 15^{mm} long. The

style is very short. Self-pollination may be effected by insect aid or may occur spontaneously by the pollen falling in the tube. The frequent visits of insects, however, render cross-pollination inevitable.

The principal visitors are butterflies; but, as commonly occurs with such flowers, long-tongued bees and flies also seek the nectar. The shorter tubes render the nectar more convenient to these insects than in the case of *P. glaberrima*. The plant blooms from May 3d to June 29th. May 8th, 16th, 17th, 31st, and June 5th, the subjoined list was observed, all the insects sucking:—

Lepidoptera—*Rhopalocera:* (1) Phyciodes tharos Dru.; (2) Pyrameis huntera F.; (3) Chrysophanus thoe B.-L.; (4) Colias philodice Gdt.; (5) Papilio asterias F.; (6) Pamphila peckius Kby.; *Heterocera:* (7) Plusia simplex Gn.

Hymenoptera—*Apidæ:* (8) Bombus separatus Cr. ♀; (9) B. pennsylvanicus DeG. ♀; (10) B. americanorum F. ♀; (11) Synhalonia speciosa Cr .♂♀.

Diptera—*Bombylidæ* (12) Bombylius atriceps Lw.

PHLOX DIVARICATA L.—This is the earliest *Phlox* in my neighborhood, blooming from April 10th to June 2d. I have given a list (14) of eleven species of Lepidoptera and four species of long-tongued bees taken on the flowers. To that list must be added the following:—

Lepidoptera—*Rhopalocera:* (16) Papilio thoas L.; (17) Eudamus tityrus F.; *Heterocera:* (18) Plusia simplex Gn.—all sucking.

On the pollination of Phlox see:

(1) Sprengel, Das entdeckte Geheimniss, 105. 1793. *P. paniculata*, proterandry, butterfly-fl.—(2) Darwin, Forms of Flowers 119–21, 287. 1877. *P. subulata*, doubtful heterostyly.—(3) Bonnier, Les Nectaires 118, 168. 1879. *P. Drummondii.*—(4) Bonnier et Flahault, Observations sur les modifications des végétaux suivant les conditions physiques du milieu. Ann. Sci. Nat. Bot. VI. 8:—1879. *P. Drummondii*, brilliancy of color changing with geographical distribution.—(5) Flahault, Nouvelles observations sur les modifications des végétaux suivant les conditions physiques du milieu. ibid. 9: 159–207. 1880. *P. Drummondii*, colored more lively in Sweden than at Paris.—(6) Francke, Einige Beiträge zur Kenntniss der Bestäubungseinrichtungen der Pflanzen. Inaug. Dessertation. Freiburg-i-B. 1883. *P. setacea.*—(7) Müller, Fertilization of flowers 407. 1883. *P. paniculata*, ref. (1), visitors.—(8) Walker, Insects and Flowers. Nature 28: 388–9. 1883. *P. sp.*—(9) Loew, Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin. Jahrb. bot. Gartens Berlin 3: 85 (17). 1884, *P. reptans, subulata*, visits of Apis.—(10) Loew, Weitere Beobachtungen, etc. ibid. 4: 153, 1886. *P. paniculata*, visit of Echinomyia.—(11) MacLeod, Untersuch-

ungen über der Befruchtung der Blumen. Bot. Centralblatt 29: 119. 1887. *P. sp.*, visit of Plusia.—(12) Kerner, Pflanzenleben. 2: 111, 1891. Protection of pollen.—(13) Peter, Polemoniaceæ, Engler und Prantl, Die nat. Pflanzenfamilien 68: 40–48. 1891. Pollination.—(14) Robertson, Flowers and Insects. Asclepiadaceæ–Scrophulariaceæ, Trans. St. Louis Acad. Sci. 5: 578. 1891.—(15) Knuth, Blütenbiologische Herbstbeobachtungen. Bot. Centralblatt 49: 363. 1892. *P. acuminata*, vis. three butterflies.

LITHOSPERMUM CANESCENS (Mx.) Lehm.—According to Müller (4, 12, 13), *L. arvense*is homogamous and regularly self-pol-linated, though there is a chance of cross-pollination when the flower first opens. According to Kerner (18 Loew 21) it is slightly proterogynous, but Müller says the anthers begin to discharge their pollen before the flower opens. *L. purpureo-coeruleum* is slightly proterogynous, with anthers and stigma of equal height (17). *L. arvense* has small white flowers, rarely with blue (Loew 21) with tubes 4–5^{mm} long. Sprengel (1) saw it visited by butterflies, and Müller (4, 12, 13) observed as visitors two butterflies, two bees and two syrphids. *L. purpureo-coeruleum*, with red flowers changing to blue (17) and tubes 8–9^{mm} long (21), and *L. officinale* with small, dull white flowers, are classed by Loew (14) as bee-flowers. In the Berlin Garden the former is visited by *Anthophora pilipes* and *Osmia aenea*, and the latter by *Megachile willughbiella*.

Bebb (5) discovered that *L. longiflorum* is only the early state of *L. angustifolium*. This and *L. canescens* are early species which are able to attract insects until about the first of June (10), when probably on account of being over-shadowed by the trees or by the later more luxuriant vegetation, the latter goes out of bloom and the former continues to produce cleistogamic flowers. Bessey (10) concludes that *L. angustifolium* is not dimorphous, but highly variable, and Halsted (16) comes to about the same conclusion. In the case of *L. canescens*, Smith (9) seems to have regarded the flower as dimorphous, but found a rare third form with "flowers differing from the ordinary dimorphous condition." Bessey (10) regards it as a case of well marked dimorphism, though according to Darwin (11) the forms are variable and the case requires further investigation. Christy (15) mentions only two forms. Halsted (16) calls it decidedly dimorphic, saying he has seen no indication of trimorphism. At Madison, Wisconsin, Trelease (MS. notes) found only two forms and regarded

the species as truly dimorphic. I have not taken great pains to examine flowers, but in all cases examined I have found indication of nothing but dimorphism.

In my neighborhood, *Lithospermum canescens* is the earliest butterfly-flower, blooming from March 18th to June 12th. The stems, often several from the same base, rise from 1 to 3^{dm} The racemes as they uncoil expose two or three erect orange-yellow flowers. The corolla is salver-form. The five-lobed border expands about 15^{mm}. The tube is about 8^{mm} long. At the throat it is narrowed to a diameter of about 1^{mm} by appendages whose purpose seems to be to restrict the visitors to slender tongues. The orange-yellow color and the narrow tube indicate an adaptation to butterflies, but the flowers are also visited by long-tongued bees. On April 30th, May 1st, 2nd, 17th, 20th, and June 5th the visitors observed were:

Lepidoptera—*Rhopalocera:* (1), Pyrameis huntera F.; (2) Chrysophanus thoe B.-L.; (3) Colias philodice Gdt., very ab.; (4) Papilio ajax L'; (5) P. asterias F.; (6) Nisoniades icelus Lint.

Hymenoptera—*Apidæ:* (7) Bombus americanorum F. ♀, ab.; (8) Synhalonia speciosa Cr. ♂ ♀, ab.; (9) Osmia cobaltina Cr. ♀, one.

Diptera—*Bombylidæ:* (10) Bombylius major L.—all sucking.

On the pollination of *Lithospermum* see:

(1) Sprengel, Das entdeckte Geheimniss 88. 1793.—(2) Kuhn, Einige Bemerkungen über Vandellia und den Blüthenpolymorphismus. Bot. Zeit. 25: 67. 1867. *L.*, heterostyled dimorphism in.—(3) Axell, Om anordningarna för de fanerogama växternas befruktning 22, 99. 1869. Ref. (2).—(4) Müller, Befruchtung der Blumen 270. 1873.—(5) Bebb, Lithospermum longiflorum only L. angustifolium. Am. Nat. 7: 691. 1873.—(6) Lubbock, British Wild Flowers in Relation to Insects 132. 1875. *L. arvense*, ref. (4)—(7) Henslow, On the self-fertilization of plants 375. 1877. *L. arvense*, ref. (6)—(8) Bonnier, Les Nectaires 125, 1879. *L. arvense.*—(9) Smith, Trimorphism in Lithospermum canescens. Bot. Gaz. 4: 168. 1879.—(10) Bessey, The supposed dimorphism of Lithospermum longiflorum (L. angustifolium). Am. Nat. 14: 417–21. 1880.—(11) Darwin, Forms of flowers. 2nd edit. 1880. *L. canescens* and *longiflorum*, ref. (9) and (10).—(12) Müller, Weitere Beobachtungen 3: 16. 1882.—(13) Müller, Fertilization of Flowers 417–18. 1883. *L. arvense*, pollination. *L. canescens*, *longiflorum*, ref. (11)—(14) Loew, Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin. 1884. *L. arvense*, 8. *L. purpureo-coeruleum*, 38, 49, *L. officinale*, 45.—(15) Christy, Heterostyled plants. Journ of Bot. 23: 49–50, 1885. *L. canescens*, *hirsutum*, relative abundance of long and short-styled fls.—(16) Halsted, Notes upon Lithospermum. Bot. Gaz. 14: 202–3. 1889.—(17) Kirchner, Beiträge zur Biologie der Bluthen. Progr. z. 72 Jahresfeier d. K. Würtemb. landwirthschaftl. Akademie Hohenheim 51. 1890.—(18)

Kerner, Pflanzenleben. 2: 1891. *L. purpureo-coeruleum*, color change, 190. *L. arvense*, autogamy, etc., 309, 330.—(19) Loew, Blüthenbiologische Beiträge II. Pringsheim's Jahrbücher, **23**: 52–3. 1892. *L. purpureo-coeruleum*.—(20) Mac Leod, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Bot. Jaarboek 5: 335. 1893. *L. arvense*.—(21) Loew, Blütenbiologische Floristik 282. 1894. *L. arvense, purpureo-coeruleum*.

PHYSALIS LANCEOLATA Michx.—According to Kirchner (2) *P. alkekengi* is proterogynous. The anthers finally approach the stigma until autogamy may occur. Kerner (3) states that autogamy results from the lengthening of the corolla.

Physalis lanceolata is common. The stem rises 3^{dm} or more and bears numerous pendulous flowers, which expand about 20^{mm}. The flowers are yellowish, the centers usually marked with five dark purple spots. The nectar is lodged in grooves alternating with the filaments, each groove being bounded on each side by a line of dense hairs. To reach the nectar, bees thrust their proboscides between the bases of the filaments. The broad bases of the filaments with the alternating tufts of hair nearly close the tube. The tufts aid in concealing the nectar and probably aid the bees in clinging to the pendulous flower.

The anthers dehisce in succession, so that to collect all of the pollen, the bees must visit each flower several times. Cross-pollination results from the stigma being in advance of the anthers and being touched before them. There may be slight proterogyny and in absence of insects autogamy may occur as in *P. alkekengi*. *P. lanceolata* blooms from May 12th to Sept. 21st. It is visited regularly and abundantly by (1) *Colletes latitarsis* Rob. ♂♀, s. and c. p., July 6th, Aug. 7th, Sept. 5th, 21st; (2) *C. willistonii* Rob. ♂♀, s. and c. p. May 29th, June 7th, 11th, Sept. 5th.

PHYSALIS VIRGINIANA Mill.—This species resembles the preceding. It blooms from June 7th to Oct. 4th and is visited for nectar and pollen by *Colletes latitarsis* Rob. ♂♀, ab., July 6th, 9th, 22nd, 25th, 26th, and *Halictus pectinatus* Rob. ♀, c. p., two, June 25th.

PHYSALIS PHILADELPHICA Lam.—This also agrees with *P. lanceolata* in most essential particulars. It was noted in bloom from July 12th to Sept. 27th. The flowers are visited for pollen by *Colletes latitarsis* Rob. ♀, July 27th.

The species of *Physalis* occurring in my neighborhood are

remarkable for their close mutual relation with two bees of the genus *Colletes*. As far as known, *Heuchera hispida*[7] is the only other flower adapted to a bee of this genus. On twelve days, between May 29th and Sept. 21st, I found the flowers to be visited by these bees and by no other insects, except the *Halictus* taken on *P. Virginiana*.

I have taken single females of *Colletes latitarsis* on flowers of *Asclepias incarnata* (entrapped and dead) and *Polygonum hydropiperoides*. Both sexes are abundant on *Physalis*, and the female seems to depend exclusively upon the pollen of these flowers.

I have taken *Colletes willistonii* on flowers of *Rhus glabra* and *Melilotus alba*, but have never seen it collecting any pollen except of *Physalis*.

On the pollination of Physalis see:

(1) Sprengel, Das entdeckte Geheimniss 127–8. 1793. *P. alkekengi*, *pubescens*, nectar-glands, guides, etc.—(2) Kirchner, Neue Beobachtungen über die Bestäubungseinrichtungen einheimischer Pflanzen, Progr. d. 68 Jahresfeier d. K. Würtemb. landwirtsch. Akademie Hohenheim. 1886.--(3) Kerner, Pflanzenleben. **2**: 1891. Protection of pollen, 118, "revolverblüthen," 250, autogamy, 361.—(4) Wettstein, Solanaceæ. Engler u. Prantl, die nat. Pflanzenfamilien 65: 8. 1891. *P.*, pollination of.—(5) Loew, Blütenbiologische Floristik 285. 1894. *P. alkekengi*, ref. (2 and 3).

MIMULUS RINGENS L.—The flowers of *Mimulus* are homogamous. Bees entering the corolla first touch the stigma, which closes up and exposes the anthers behind it. Self-pollination occurs in *M. luteus*, but Darwin (13) found that pollen from another plant was prepotent over the flower's own pollen. He saw *M. roseus* visited by bees. According to Batalin (6) *M. guttatus* is visited by bees.

The irritability of the stigma of *Mimulus* was well known to Kurt Sprengel (1), Braconnot (2) and Vaucher (3). The latter mentions it as occurring in *M. luteus* and *glutinosus*, and supposes that it occurs in other members of the genus. This has been verified to such an extent that now it seems that a *Mimulus* without an irritable stigma would be a desideratum. Delpino (4, 7) was first to indicate the advantage of the movement in facilitating cross-pollination.

In the case of *Mimulus ringens*, Meehan (17) states that the stamens dehisce and the stigmas generally show pollen before the flowers are quite open. He observes the movement of

[7] Bot. Gaz. **17**: 178. 1892.

the stigma, and is the only one who does not regard it of any advantage. According to Beal (18) a student, Penoyer, has proved by detailed experiment that the flower is not self-pollinating. Foerste (25) observes that cross-pollination is not insured, and that the tubes are too long for the smaller bees.

The flowers are violet purple, the yellow palate forming a path-finder. The stigma slightly exceeds the anthers. I have found the lower lobe of the stigma with its tip touching the pollen. But most of the stigmatic surface remains exposed and may be thoroughly dusted with pollen from another flower. The corolla tube measures about 19^{mm}, but bees can insert their heads for about 5^{mm}, so that a tongue 14^{mm} long can exhaust the nectar. The plants are frequent in wet places, the stems growing from 11 to 14^{dm} high. The flowers were observed in bloom from July 11th to September 7th. They are visited for nectar by *Bombus americanorum* F. ♀☿.

MIMULUS ALATUS Soland.—See Foerste (25).—This flower is also adapted to bumblebees. It resembles the preceding, but the palate is larger, paler, and more strongly bearded. The tube measures 18^{mm} long. Bees can insert their heads for about 7^{mm} and drain the tube with a proboscis 11^{mm} long. As in *M. ringens*, the stigma finally touches the pollen and may be self-pollinated, but I am inclined to believe that the flowers are seldom neglected for a whole day, and are regularly cross-pollinated by bumblebees. The plants are not so tall as in *M. ringens*. They bloom from July 13th to Sept. 7th. The flower is visited for nectar by *Bombus americanorum* F.☿.

On the pollination of Mimulus see:

(1) Sprengel, Anleitung zur Kenntniss der Gewächse 1: 192, 274. 1817.—(2) Braconnot, Sur l'irritabilité du stigmate des Mimulus. Ann. de Chim. et de Phys. **29**: 333–4. 1825.—(3) Vaucher, Histoire physiologique des Plantes d' Europe **3**: 525. 1841.—(4) Delpino, Sugli apparecchi della fecondazione nelle piante antocarpee 32. 1867.—(5) Hildebrand, Federigo Delpino's Beobachtungen über die Bestäubungseinrichtungen bei den Pflanzen. Bot. Zeit. **25**: 284. 1867. *M. glutinosus* (*Diplacus puniceus* Nutt.), irritable stigma.—(6) Batalin, Beobachtungen über die Bestäubung einiger Pflanzen. Bot. Zeit. **28**: 53–4. 1870. Sensitive stigma, etc.—(7) Delpino, Ulteriori osservazioni. II. **2**: 151. 1873.—(8) Müller, Befruchtung der Blumen 283. 1873.—(9) Kitchener, On cross-fertilization as aided by sensitive motion in musk and Achimenes. Jour. of Bot. **2**: 101–3. Am. Nat. **7**: 478–80. 1873. *M. moschatus*.—(10) Kitchener, A Year's Botany 118. 1874. Significance of sensitive stigma. Cit. by Darwin (13).—(11) Heckel, Du mouvement dans les stigmates bilobiés des Scrophularinées, des Bignoniacées et des Sésamées. Comptes Rendus **79**: 702–4. 1874. Cit. by

Miyoshi (28).—(12) Heckel, Sur la motilite dans quelques organes reproducteurs des Phanerogames. Thèse pour le doctorat ès sci. naturelles. 1875.—(13) Darwin, Cross and self-fertilization of plants. 1876. *M. roseus*, irritable stigma and visitors, 63. *M. luteus*, extended observations.—(14) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. **1**:—1877. *M. luteus*, review of Darwin's observations.—(15) Behrens, Beiträge zur Geschichte der Bestäubungstheorie. Progr. d. Kgl. Gewerbschule zu Elberfeld 24–5. 1877–8. *M. luteus* (*Tilingii*), sensitive stigma, homogamy, etc.—(16) Heckel, Des relations que presentent les phénomènes propres aux organes reproducteurs de quelques Phanérogames avec la fécondation croisée et la fécondation directe. Comptes Rendus **87**: 697–700. 1878. Sensitive stigmas and pollination.—(17) Meehan, Irritable or sensitive stamens. Proc. Acad. Sci. Phila. **1878**: 333.—(18) Beal, The agency of insects in fertilization. Am. Nat. **14**: 202. 1880.—(19) Behrens, Blumen und Insekten. Methodisches Lehrbuch der Botanik für hohere Lehranstalten. 1880. *M. luteus* (*Tilingii*).—(20) Thompson, Fertilization of New Zealand flowering plants. Trans. New Zeal. Institute **13**: 241–88. 1880. *M. luteus*.—(21) Meehan, The stigma of Catalpa. Bot. Gaz. 8: 191. 1883. Stigma of common garden *M.* closes in fifteen seconds.—(22) Müller, Fertilization of Flowers 436. 1883. *M. luteus* (*guttatus*, *Tilingii*), *puniceus*, ref. (5, 6, 15)—(23) Hoffmann, Culturversuche über Variation. Bot. Zeit. **42**: 216. 1884. *M. cardinalis* × *moschatus*, fruitful.—(24) Oliver, Ueber Fortleitung des Reizes bei reizbaren Narben. Ber. deut. bot. Gesellsch. **5**: 162–9. 1887. *M. luteus*, *cardinalis*.—(25) Foerste, Notes on structures adapted to cross-fertilization. Bot. Gaz. **13**: 153. 1888. *M. alatus*, *ringens*.—(26) Hansgirg, Ueber die Verbreitung der reizbaren Staubfäden und Narben, etc. Bot. Centralblatt **43**: 413. 1890. *M. ringens*, *purpureus*, *Lewissii*, *Californicus*, *parviflorus*, *moschatus*, *cardinalis*, *luteus*, (*Roezlii*, *cupreus*, *guttatus*, *Tilingii*).—(27) Kerner, Pflanzenleben **2**: 127, 253, 280. *M. luteus*.—(28) Miyoshi, Notes on the irritability of the stigma. Journ. of Sci. Imp. Univ. Tokio **1891**: 211. *M. Nepalensis*, *sessilifolius*, *moschatus*.—(29) Wettstein, Scrophulariaceæ. Engler und Prantl, Die nat. Pflanzenfamilien 65: 46–7. 1891. Pollination.

Carlinville, Illinois.